Smith Slough and Smith Ditch Fisheries Enhancement Project

Preliminary Design Report




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Appendix A – Preliminary Design Sheets – Smith Slough and Smith Ditch Fisheries Enhancement Project

1 Project Background

The Big Hole River flows through a large alluvial valley that contains many low order tributaries. While much of the river exhibits excellent aquatic and riparian habitat features, human influences along the Big Hole River are evident throughout the valley bottom where agriculture development, livestock production, and irrigation practices occur. Numerous diversion structures are present along the river and floodplain areas have been modified to improve agricultural operations and provide county road crossings. The combination of several factors including irrigation withdraws, loss of wetlands, and the development of side channels into ditches has led to a reduction in fisheries productivity and thermal impairments in lower segments of the Big Hole River.

As a result, the lower Big Hole River has received recent attention for watershed issues that contribute to water quality impairments and reduced fisheries production. In 2012, the Big Hole Watershed Committee (BHWC) prepared a restoration plan for the lower Big Hole River corridor which identified several projects capable of addressing one or more resource concerns. The Smith Slough and Smith Ditch Fisheries Enhancement Project was identified as high priority due to its potential for fisheries habitat improvement, irrigation improvements, water conservation, isolating a source of warm water to the Big Hole River, and landowner interest.

The following report and accompanying design sheets constitute a preliminary design for the Smith Slough and Smith Ditch Fisheries Enhancement Project. The purpose of this preliminary design is to provide alternatives for fisheries habitat and water quality improvements within the project area. The preliminary design report includes narrative descriptions of each proposed project component and cost estimates for each alternative/option. Design sheets, including plan view, profile, and cross section views of proposed fisheries enhancement options are provided in Appendix A.

2 Project Goals

The goals of the Smith Slough and Smith Ditch Fisheries Enhancement Project are to:

1. Improve adult fisheries habitat.
2. Improve spawning habitat for salmonids including rainbow and brown trout.
3. Improve water quality by reducing thermal inputs to the lower Big Hole River corridor.

3 Project Location

The project reach is approximately 3.5 miles southwest of Twin Bridges, Montana, and includes the 2-mile long Smith Slough and the 1-mile long Smith Ditch (Figure 1).

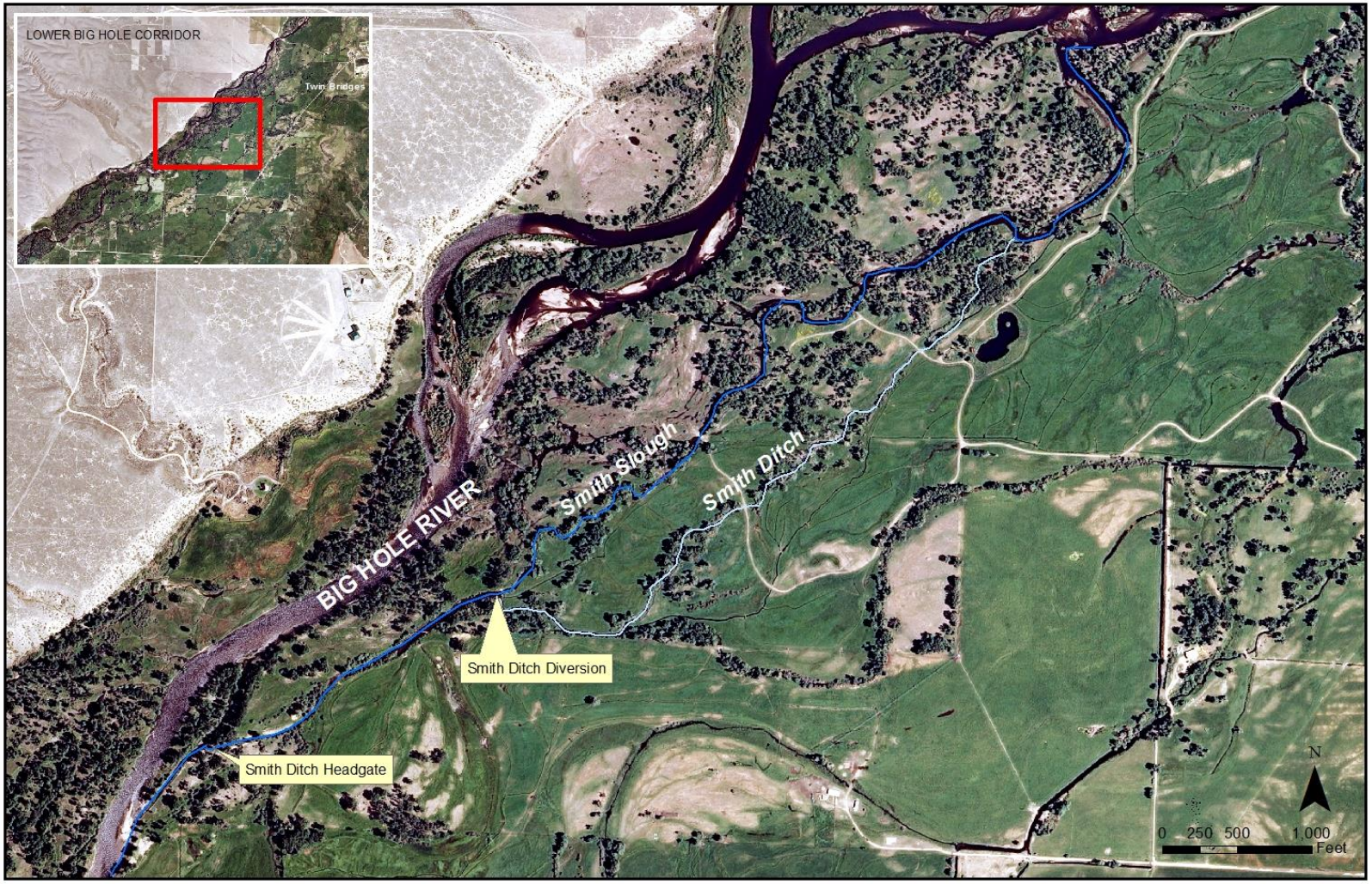

Figure 1. Location of Smith Slough and Smith Ditch Fisheries Enhancement Project.

4 Existing Conditions and Contributing Factors

The following section describes existing conditions of irrigation infrastructure, the Smith Slough, and the Smith Ditch, and how present conditions limit fisheries habitat and contribute to water quality impairments within the project reach. For the purposes of describing existing conditions and proposed improvement alternatives, the Smith Slough and Smith Ditch have been divided into the reaches shown in Table 1. Channel stations are shown on the plan view design sheets 3, 4, and 5 in Appendix A.

Table 1. Reach breaks and extents of the Smith Slough and Smith Ditch

Segment	Reach	Upstream Station	Downstream Station	Description
Smith Slough	1	107+00	95+00	Big Hole diversion to Smith Ditch headgate
	2	95+00	73+00	Smith Ditch headgate to Smith Ditch diversion
	3	73+00	44+00	Smith Ditch diversion to overflow channel
	4	44+00	21+00	Overflow channel to upstream end of oxbow
	5	21+00	0+00	Upstream end of oxbow to confluence with Big Hole
Smith Ditch	1	50+00	0+00	Entire length of Smith Ditch

Longitudinal profiles and cross sections of the Smith Slough and Smith Ditch were surveyed in April, 2014 to assist in preparing a preliminary design and habitat enhancement alternatives for the project reach. Stream bed slope and cross section dimensions reaches of the Smith Slough and Smith Ditch are summarized in Table 2.

Table 2. Smith Slough and Smith Ditch stream bed slope and cross section parameters.

Reach	Station	XS	NOTE	Channel Slope	Bankfull Width (ft)	Max Depth (ft)	XS Area (sq ft)	Perimeter (ft)	Mean Depth (ft)	W/D Ratio
Smith Slough Reach 2	82+96.9	13	Upper R2 - riffle	0.39%	20.93	1.79	28.54	22.28	1.36	15.35
	91+44.8	14	Upper R2 - ditch, cobble bank		21.02	2.85	36.58	22.02	1.74	12.08
	73+86.9	11	Lower R2 - overwide pool	0.03%	50.62	3.21	123.24	52.17	2.43	20.79
	75+87.6	12	Lower R2 - narrow to riffle		40.72	2.02	66.33	41.87	1.63	25.00
Average - Upper Reach 2					**20.98**	**2.32**	**32.56**	**22.15**	**1.55**	**13.71**
Average - Lower Reach 2, backwatered					**45.67**	**2.62**	**94.79**	**47.02**	**2.03**	**22.89**
Smith Slough Reach 3	44+99.0	6	Reference riffle	0.37%	21.62	1.44	22.55	22.19	1.04	20.73
	50+32.4	7	Overwide pool		38.70	3.18	93.74	40.69	2.42	15.98
	53+69.7	8	Reference riffle		13.98	1.00	11.33	14.56	0.81	17.25
	56+60.5	9	Reference pool		21.79	2.47	39.51	23.72	1.81	12.02
	65+65.4	10	Reference pool		24.03	3.72	56.42	25.44	2.35	10.23
Average Reach 3 Reference Riffles					**17.80**	**1.22**	**16.94**	**18.38**	**0.93**	**18.99**
Average Reach 3 Reference Pools					**22.91**	**3.10**	**47.97**	**24.58**	**2.08**	**11.13**
Smith Slough Reach 4	22+56.6	1	Overwide Pool	0.31%	77.91	3.45	192.77	79.19	2.47	31.49
	27+79.6	2	Overwide Riffle		62.70	1.32	54.83	62.98	0.87	71.70
	30+75.9	3	Overwide Riffle		51.84	2.51	85.78	52.25	1.65	31.33
	32+16.3	4	Overwide Pool		39.66	2.47	66.89	40.39	1.69	23.51
	37+18.4	5	Overwide Riffle		31.86	2.34	59.98	33.01	1.88	16.92
Average Reach 4 Overwide Riffles					**48.80**	**2.06**	**66.86**	**49.41**	**1.47**	**39.98**
Average Reach 4 Overwide Pools					**58.79**	**2.96**	**129.83**	**59.79**	**2.08**	**27.50**
Smith Slough Reach 5	4+27.0	O1	Oxbow	0.21%	60.50	2.36	113.31	61.57	1.87	32.30
	6+57.6	O2	Oxbow		68.05	2.72	150.00	69.33	2.20	30.87
	10+30.5	O3	Oxbow		44.67	4.03	128.33	46.67	2.87	15.55
	13+01.6	O4	Oxbow		49.90	3.34	120.10	51.12	2.41	20.73
Average Reach 5 Oxbow Sections					**55.78**	**3.11**	**127.94**	**57.17**	**2.34**	**24.86**

Reach	Station	XS	NOTE	Channel Slope	Bankfull Width	Max Depth	XS Area	Perimeter	Mean Depth	W/D Ratio
Smith Ditch Reach 1	3+43.8	14	Steep riffle	0.34%	12.33	1.66	15.57	14.29	1.26	9.76
	6+11.8	15	Potential spawning reach		13.18	1.94	20.40	15.31	1.55	8.52
	9+28.5	16	Potential spawning reach		16.54	1.48	20.11	17.36	1.22	13.60
	17+80.1	17	Reference pool		17.87	2.75	38.42	19.92	2.15	8.31
	23+56.5	18	Potential spawning reach		16.80	2.58	35.28	19.19	2.10	8.00
	27+18.1	19	Reference pool		19.01	1.71	22.79	20.00	1.20	15.86
	30+14.1	20	Reference pool		15.05	2.05	21.29	16.82	1.41	10.64
	31+18.8	21	Spawning riffle, wide		25.03	2.18	40.66	26.56	1.62	15.41
	37+07.4	22	Tie-in, spawning riffle		47.88	1.69	52.90	48.44	1.10	43.34
	42+69.3	23	Wide, poor habitat		26.18	3.04	59.23	27.79	2.26	11.57
	46+30.3	24	plug		27.97	2.72	61.69	29.79	2.21	12.68
Average - Smith Ditch pools					**17.31**	**2.17**	**27.50**	**18.91**	**1.59**	**11.60**
Average - Smith Ditch riffles					**21.96**	**1.92**	**30.82**	**23.53**	**1.48**	**16.44**

4.1 Smith Slough - Reach 1

Reach 1 of the Smith Slough includes a diversion off the Big Hole River down a braid of the river to the Smith Ditch headgate. The braid of the river was formed naturally, and has been periodically dredged to maintain efficient conveyance of irrigation water to the Smith Ditch headgate (Figure 2). High water and flooding in 2011 redistributed rock and woody materials, creating a large gravel point bar and debris jam that prevented adequate flows from being diverted into the channel braid. Emergency modifications were done in 2011 at the diversion in order to sustain flows to the headgate.

The gravel point bar has continued to develop on the inside of the meander bend at this diversion, causing the need for continuous maintenance to maintain water delivery to the headgate. Maintenance at the diversion requires excavating deposits and building gravel berms to divert water down the braid toward the Smith Ditch headgate. The configuration of the Big Hole River will likely continue to deposit gravels and cause conveyance issues at this diversion for the foreseeable future.

Figure 2. Point of diversion from Big Hole River toward Smith Ditch headgate.

The Smith Ditch headgate is located on the channel braid approximately 600 feet downstream from the diversion. A small gravel berm was built to divert water from the braid through the headgate into a former side channel of the Big Hole River. The headgate is comprised of wooden boards with a metal structure constructed form an old boiler pipe (Figure 3). The stability of the structure has been compromised due to age and it is difficult to control the quantity of water diverted through the structure.

Water rights allow diversion of up to 600 inches (15 cfs) from the Big Hole River through the Smith Ditch headgate and through the Smith Slough and Smith Ditch system during the irrigation season (May through October). Between 300 and 500 inches (7.5 – 12.5 cfs) remains diverted through the winter months (November through April) for livestock.

Figure 3. Smith Ditch headgate at the head of the Smith Slough.

4.2 Smith Slough – Reach 2

Reach 2 of the Smith Slough extends 2,200 feet from the Smith Ditch headgate to the Smith Ditch diversion structure. The upper end of this reach is a straight, dredged channel segment (Figure 4). Dredge piles line this segment, which lacks habitat complexity and pool development due to its straight alignment. The lower half of Reach 2 is regularly backwatered by the Smith Ditch diversion structures. Operation of the Smith Ditch diversion involves the use of check boards across the Smith Slough to divert irrigation water into the Smith Ditch (Figure 5) as necessary to flood irrigate several hundred acres of hay pastures. The check structure causes a backwatering effect which extends approximately 800 feet upstream. The backwatered reach has become wide and shallow due to sediment deposition, resulting in poor fish habitat.

Channel cross section data surveyed in the upper and lower segments of Reach 2 illustrate the effects of the Smith Ditch diversion on the channel. Average cross section widths increase from 21 to 46 feet due to the backwatering effects of the diversion structure and subsequent sediment deposition (Table 2).

In addition to habitat impairments through Reach 2, fish passage may be compromised during seasonal use of the Smith Ditch diversion structure. Check boards placed across the channel likely impede upstream fish movements during the irrigation season from May through October.

Figure 4. Straight segment in upper extent of Reach 2 of Smith Slough.

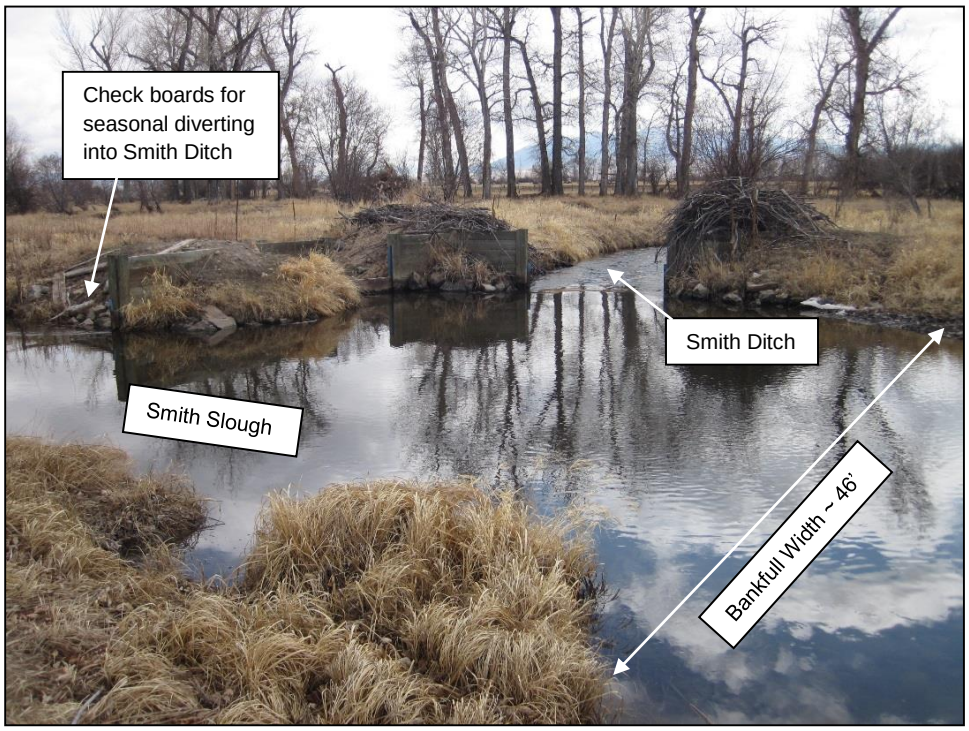

Figure 5. Smith Slough at Smith Ditch diversion.

4.3 Smith Slough – Reach 3

Reach 3 of the Smith Slough extends 2,900 feet from the Smith Ditch diversion downstream to the confluence with an overflow channel of the Big Hole River. Downstream of the Smith Ditch diversion, the channel flows through a naturally formed side channel with relatively good fish habitat complexity and a naturally meandering planform configuration (Figure 6). Flow diversion down the Smith Ditch has resulted in a reduced frequency of larger magnitude flows capable of scouring deep pools in Smith Slough. As a result, the existing pool features within Reach 3 may have slightly limited lengths and depths.

Cross section surveys through Reach 3 indicate an average bankfull width of 18 feet at riffles and 23 feet at pools (Table 2). Given the relatively good habitat parameters exhibited through Reach 3, these dimensions may be used as a guide toward developing reference design dimensions in other reaches of the Smith Slough.

Figure 6. Improved aquatic habitat exhibited through Reach 3 of Smith Slough.

4.4 Smith Slough – Reach 4

Reach 4 of the Smith Slough extends 2,300 feet from the confluence of an overflow channel of the Big Hole River to the upstream end of a long oxbow bend. The Slough becomes significantly wider in Reach 4 as compared to Reach 3, and was likely once a larger, active braid of the main stem river. This reach remains isolated from the main stem river during base

flows and only connects during larger, overbank events. This historic braid of the Big Hole is dominated by large alluvial cobbles, which do not readily scour when subjected to the typical discharges delivered through the Smith Ditch headgate, the Smith Ditch diversion, and down the Slough through Reach 3. As a result, pool frequency and depths throughout Reach 4 are low, as typical discharges through this reach are incapable of scouring the larger cobble substrate necessary to generate deep water habitats.

Riffle widths surveyed through Reach 4 averaged 49 feet, while pool widths averaged 59 feet (Table 2), which were more than double the widths surveyed through Reach 3. The generally wide and shallow channel configuration through Reach 4 results in slow water velocity and may contribute to thermal inputs during summer base flows.

Figure 7. Typical wide and shallow segment with low pool frequency in Reach 4 of the Smith Slough.

4.5 Smith Slough – Reach 5

The Smith Ditch returns back to the Smith Slough at the upstream end of Reach 5. Once these channels combine, they run 2,000 feet through a large, wide oxbow of the Big Hole River. This oxbow feature was once a larger braid of the main stem river, and currently receives far less discharge than during the era in which it formed. The oxbow connects with the main stem of the Big Hole River at the downstream extent of the project reach. Water velocities through the oxbow are very low due to the combination of an overly wide cross section and relatively flat channel slope through Reach 5 (0.21%) as compared to Reaches 3 and 4 (0.37% and 0.31%,

respectively). Channel widths average 56 feet, and are indicative of significantly higher discharges than currently run through this channel segment. Fine sediments smother the larger river cobbles and gravels throughout the length of the oxbow. Poor habitat complexity throughout Reach 5 likely limits fish movements from the main stem river into the more suitable habitat available in the Slough. Furthermore, the wide and shallow oxbow configuration provides a source of thermal heating of water flowing through the Slough before re-entering the main stem of the Big Hole River.

Figure 8. Oxbow bend segment of Smith Slough through Reach 5.

4.6 Smith Ditch

The Smith Ditch is diverted from the Smith Slough and flows approximately 5,000 feet before returning back to the Slough at the upstream end of Reach 5. This ditch has historically been used to convey diverted water to a series of flood irrigation ditches and through several hundred acres of hay fields. The ditch is actually a small, historic side channel of the Big Hole River, therefore aquatic habitat throughout the majority of the channel length is good, with relatively high pool frequency and periodic cover provided by woody debris. Bankfull channel widths average 22 feet for riffles and 17 feet for pools (Table 2). The Smith Ditch remains isolated from the main stem Big Hole River during all but the highest flood events.

Discharges down the Smith ditch have been regulated over many years; therefore the banks have remained stable and well vegetated. If discharges are carefully managed through the Smith Ditch, this channel may be effectively managed much like a spring creek channel that is not subject to regular flashy flood events.

Figure 9. Typical riffle/pool segment found within the Smith Ditch.

5 Recommendations for Improving Fisheries Habitat and Water Quality

The following section provides a series of recommended approaches to improve water quality and habitat throughout the project area. These recommendations will improve upon existing conditions for all life stages of trout found within the lower Big Hole River.

5.1 Water Conservation Practices (currently being implemented)

New landowners are currently converting from flood irrigation practices to a pivot sprinkler system across a large area formerly served by the Smith Ditch system. The conversion of flood to sprinkler irrigation is expected to reduce irrigation demand from the Smith Ditch system from 600 to 80 inches (15 cfs to 2.0 cfs), allowing for up to 520 inches (13 cfs) of water to remain in the Smith Slough and/or the Smith Ditch channels. This reduction in consumptive use provides an excellent opportunity to improve fisheries habitat in both channel segments by utilizing water formerly used as irrigation for in-stream flows. The newly installed pivot system will draw water downstream of the confluence of the Smith Slough and the Smith Ditch within Reach 5, therefore all water savings will remain in the slough and ditch systems throughout the majority of the project reach.

5.2 Develop Flow Management Plan for Smith Slough and Smith Ditch

The additional 13 cfs of water available may be effectively divided between the Smith Slough and Smith Ditch to support and enhance habitat for various life stages of fish. The Slough is a slightly larger channel periodically subject to overbank flows from the main stem of the Big Hole River. Existing pool features are slightly deeper than in the Smith Ditch, offering suitable habitat for adult and overwintering fish. The Smith Ditch is slightly smaller, and is isolated from the main stem Big Hole overbank flows. As a result, it may be managed more like a spring creek system, with flows regulated through the Smith Ditch diversion structure. Developing a flow management plan and installing devices to measure discharge in each channel will maximize habitat suitability within each channel segment.

For example, a flow management plan may designate 8 cfs as the target flow to remain in the Smith Slough for support of adult trout habitat features, while the remaining 5 cfs would be diverted down the Smith Ditch to support spawning and rearing fish. Pool and riffle features in each channel segment may be enhanced to provide the most beneficial habitat under any given flow scenario (e.g. constructing spawning runs that flow between 1-2 feet/second and 0.5 – 2 feet deep at 5 cfs during the spawning seasons).

5.3 Fisheries Habitat Improvements – Smith Slough

Several opportunities exist to improve fisheries habitat within the Smith Slough. Proposed habitat enhancement actions include:

Reach 2 Habitat Improvements:

Approximately 800' of the Smith Slough upstream of the Smith Ditch diversion is seasonally backwatered, causing sediment deposition and an over-wide channel configuration. This reach of the Slough could be narrowed and deepened to a more appropriate width/depth ratio by excavating gravels, constructing a new bank, and removing fine sediment deposits. This technique has proved effective at improving fish habitat and reducing thermal inputs by establishing a more appropriate channel width, and constructing deeper pool features. Plan views of proposed planform habitat improvements in Reach 2 are illustrated on Design Sheet 3 in Appendix A. Typical cross sections illustrating this technique are included on Design Sheet 8.

If placement of check boards in the Smith Ditch diversion structure is necessary to achieve flow goals developed in the flow management plan, the structure should be outfitted with a fish ladder to maintain passage during all discharges. The existing diversion structure is in good condition; therefore a simple denil ladder retrofit would be sufficient to provide passage at the structure.

The existing Smith Ditch headgate is in need of replacement to reduce maintenance requirements, maintain stability, and provide added control of discharges down the Slough. A new headgate would enable limiting flows down the Slough during runoff periods to protect habitat enhancement work, and include a measuring device to regularly determine discharge through the structure.

Benefits of proposed habitat enhancements through Reach 2 include:

- Improved habitat complexity by creating narrower and deeper pools
- Improved sediment transport through backwatered segment of Reach 2
- Narrowed channel to reduce thermal inputs generated from existing wide channel configuration through backwatered segment
- Improved fish passage at Smith Ditch diversion structure
- Reduced maintenance and improved stability and control at the Smith Ditch headgate

Reach 3 Habitat Improvements:

The majority of Reach 3 exhibits good fish habitat complexity and planform elements. As a result, cross section dimensions exhibited within this reach may be used as a reference for designing prescribed channel alterations in the over wide segments found within Reaches 2, 4, and 5. Short segments within Reach 3 are suitable for pool enhancements as well, which would involve excavating gravels to establish habitat for adult and overwintering fish. Plan views of proposed locations for pool habitat enhancements in Reach 3 are illustrated on Design Sheet 4 in Appendix A.

Benefits of proposed habitat enhancements in Reach 3 include:

- Improved deep water pool features for adult fish habitat
- Improved habitat for over-wintering fish

Reach 4 Habitat Improvements:

Channel dimensions in Reach 4 exhibit much wider bankfull widths due to the influence of a historically larger channel running through this reach of the Slough. The existing channel dimensions do not favor use by fish due to over wide and relatively shallow depths. Channel cross section dimensions may be altered to create more favorable habitat elements, improve sediment transport, and reduce thermal inputs throughout the reach.

Proposed habitat alterations include excavating gravels and cobbles from the stream bed to form deeper pool features and constructing new banks to narrow the channel top width. Newly constructed stream banks will generate a channel width more indicative of Reach 3, which exhibits superior habitat conditions. Plan views of proposed locations for channel narrowing and pool enhancements in Reach 4 are illustrated on Design Sheet 5 in Appendix A. Typical cross sections illustrating this technique are included on Design Sheet 8.

Benefits of proposed habitat enhancements in Reach 4 include:

- Improved habitat complexity by creating narrower and deeper pools;
- Improved sediment transport through Reach 4
- Reduced thermal inputs by reconstructing existing, wide and shallow configuration to narrower and deeper channel

Reach 5 Habitat Improvements:

The Smith Ditch re-enters the Slough at the head of Reach 5, and the combination of flows from both channels then flows through a wide and flat oxbow meander. Poor habitat complexity and thermal inputs through this reach result in unfavorable conditions for trout to migrate back and forth from the main stem into the Slough system. Proposed habitat improvements are intended to create more attractive habitat within Reach 5 and better connect the adult and spawning habitats within the Smith Slough and Smith Ditch systems to the main stem Big Hole River.

Proposed channel alterations through Reach 5 are similar to those proposed in Reach 4, and include excavating cobbles/gravels from the stream bed to create a series of gravel banks capped with wetland sod mats to narrow the cross section (See Design Sheets 5 and 8, Appendix A for proposed plan view and cross sections). Cross section dimensions of narrowed reaches will provide improved habitat, deeper pools, and will be designed to convey typical discharges anticipated through the Smith Slough. All newly constructed banks will be designed to an elevation that will be submerged when high flows in the Big Hole spread into the Slough. These banks will be constructed with alluvial cobbles excavated from pools and capped with wetland sod to provide a stable bank during higher flow events.

Benefits of proposed habitat enhancement through Reach 5 include:

- Improved habitat complexity by creating pool and riffle features through oxbow segment
- Improved sediment transport through Reach 5
- Narrowed channel will reduce thermal inputs generated from existing wide and slow channel configuration

5.4 Fisheries Enhancements – Smith Ditch

Existing habitat in the Smith Ditch is generally good, with several riffle/pool sequences and stable stream banks. Occasional woody debris features provide additional habitat complexity and cover. As a result, proposed habitat enhancements focus on improving spawning conditions by installing appropriately sized gravels in segments exhibiting favorable hydraulic conditions. Conditions favoring spawning behavior include channel depths ranging from 0.5 to 2.0 feet, and water velocities averaging 1.5 feet/second. These hydraulic conditions may be optimized if a flow management plan is developed which designates a specific discharge down the Smith Ditch channel during typical spawning periods.

Spawning habitat in the Smith Ditch may be improved by replacing existing gravels (if appropriate) with a mix of gravels specifically sized for spawning success. In segments where existing bed materials are insufficient for spawning and hydraulic conditions appear favorable, the existing materials will be excavated and replaced with approximately 1.5’ of spawning gravels. Proposed locations for placement of spawning gravels are illustrated in planview on Design Sheets 3 and 4, while a cross section illustrating this technique is included in Design Sheet 8, in Appendix A. In order to maximize the effectiveness of the spawning enhancements, one element of the Smith Ditch flow management plan will specify a range of discharges capable of flushing fine sediments, yet prevent any newly installed spawning gravels from transporting downstream.

Benefits of proposed habitat enhancements in the Smith Ditch include:

- Improved spawning habitat through 5,000 feet of the Smith Ditch for fish populations present in the Big Hole River
- Regulated flow management plan to optimize hydraulics during spawning seasons

6 Habitat Enhancement Alternatives

6.1 Alternative #1a - Relocate Diversion Structure:

The location of the existing diversion off the Big Hole River creates challenges for effectively conveying water to the Smith Slough and Smith Ditch systems. The existing channel through Reaches 1 and 2 include straight ditch segments commonly dredged, poor habitat complexity, and a backwatered segment upstream of the Smith Ditch diversion. In addition to the management issues related with the existing diversion and headgate locations, Reaches 1 and 2 offer poor aquatic habitat as compared to reaches downstream.

Alternative #1 includes relocating the diversion approximately 500' upstream on the Big Hole River and realigning the upper segment of the Slough. The new diversion location will correspond to the downstream extent of a riprapped bank of the Big Hole River, which is not subject to the depositional point bar feature currently forming further downstream. Sheet 9 in Appendix A illustrates the proposed plan form and profile of the relocated diversion and newly aligned upper Slough segment. A profile running from the proposed new head gate location to the tie-in with the existing channel indicates the potential to construct an improved, 3,000 foot alignment with bed slope of 0.25%. This channel slope offers an opportunity to construct a meandering channel through the realigned upper Slough segment, which will result in improved fisheries habitat as compared to existing habitat exhibited within Reach 1.

Benefits of Alternative #1 include:

- Reducing maintenance requirements of the existing diversion due to natural point bar development in the main stem Big Hole
- Eliminating the existing and dilapidated Smith Ditch headgate to allow for more regulated flows down the Slough
- Improved fisheries habitat through 3,000 feet of the realigned Slough segment as compared to existing, channelized and dredged conditions

6.2 Alternative #1b – Relocate Smith Ditch headgate to head of Smith Ditch

Alternative #1b includes relocating the Smith Ditch headgate to the upstream extent of the Smith Slough and re-grading the upper 1,000 feet of the Smith Slough to generate additional head from the Big Hole River. The existing Smith Ditch headgate is slightly perched, reducing the ability to pass water during low flows in the Big Hole River. Relocating the headgate to the head of the Slough and reducing the elevation of the upper Slough by an average of 1.0 feet will more effectively allow water to enter the Smith Slough and Smith Ditch systems. The new headgate will be designed to allow excess water and sediment to pass back to the Big Hole River, while allowing better control of discharges down the Smith Slough. A plan view and profile of this alternative is illustrated on Design Sheet 10 in Appendix A.

6.3 Alternative #2 – Relocate upper Smith Ditch and isolate ditch returns

Wastewater and flood irrigation returns from adjacent fields collect in a large swale to the south of the Smith Ditch diversion, and discharge through a culvert directly into the Smith Slough.

These irrigation returns supply a source of heated water into the Slough, reducing water quality and suitability for fish utilizing the Smith Slough and Smith Ditch systems. Alternative #2 includes isolating this source of heated water from the Slough by relocating the upper extent of the Smith Ditch and re-routing irrigation returns through a swale into an existing ditch lateral.

Design Sheet 11 in Appendix A illustrates this alternative in planview. The upper 950 feet of the Smith Ditch (currently a straight ditch alignment) would be relocated through a low floodplain swale to the north of the existing alignment. Relocating this channel segment will improve habitat complexity by adding meanders and pool features to replace the existing straight alignment. The existing channel through this segment will be deactivated from Smith Ditch flows, and will be utilized to collect irrigation returns re-routed from in the swale.

The existing culvert at the mouth of the return swale will be plugged to prevent heated water from entering the Smith Slough. Irrigation returns collecting in the swale will be re-routed through a newly excavated drain ditch and discharge to the deactivated segment of the upper Smith Ditch. Heated water will be directed into an existing ditch lateral, and allowed to feed through several smaller flood irrigation ditches and spread across the irrigated landscape. This alternative will prevent thermally heated water from entering the Smith Slough and Smith Ditch systems, improving water quality and fisheries resource values within the project reach.

Benefits realized from Alternative #2 include:

- Elimination of a source of heated water from the Smith Slough, Smith Ditch, and Big Hole River.
- Improved habitat complexity and meander planform in 950 feet of the upper Smith Ditch.
- Elimination of potential fish losses down the ditch lateral by isolating it from perennial flows.

6.4 Alternative #3 – Realign downstream extent of Reach 5

Reach 5 of the Smith Slough flows through a wide and flat oxbow meander with poor habitat and slow water velocities. Proposed habitat enhancements through this reach may be generated by narrowing the channel as described in Section 5.3, but would be further improved by realigning the lower segment of the oxbow through a swale and tying the oxbow into the main stem river downstream from its existing confluence (See Design Sheet 12). Profile surveys of the existing channel alignment illustrate a bed slope of 0.21% in Reach 5, which is controlled by a gravel deposit near the downstream end of the oxbow. If the lower 700 feet of the oxbow were relocated through a swale further west, the elevation at its confluence with the Big Hole River would drop by 2.5 feet and increase the bed slope and water velocity through Reach 5 from 0.21% to 0.29%. The addition of 2.5 feet of grade through Reach 5 and resultant bed slope more closely matches that found through Reaches 3 and 4 (0.37% and 0.31%, respectively) of the Smith Slough, both of which exhibit better sediment transport and habitat elements where bankfull widths are appropriate.

Benefits of implementing Alternative #3 include:

- Reduction in thermal inputs through Reach 5 by increasing channel gradient and velocity
- Improved habitat enhancement potential through Reach 5 by lowering elevation of confluence by 2.5 feet and increasing reach grade from 0.21% to 0.29%
- Improved Slough habitat extended by approximately 600 feet

7 Final Design and Permitting Requirements

If implemented, the recommended habitat and water quality enhancements and alternatives proposed in this preliminary design report will require additional design details to secure all necessary regulatory permits and bid construction elements using State of Montana procurement procedures. Anticipated regulatory permits required for this project include:

- Madison County Conservation District 310 permit
- U.S. Army Corps of Engineers 404 permit
- DEQ 318 permit for temporary increase in turbidity
- Madison County Floodplain Permit (may be reviewed by DNRC due to scale and complexity of project)

The following final design elements are recommended prior to submitting permit application materials and procuring construction activities:

Replace Smith Ditch Headgate:

- Hydraulics at existing Smith Ditch headgate location to ensure replacement structure is structurally stable to withstand the 100-year flood event (as required for County Floodplain Permit)
- Hydraulics at headgate to ensure size of replacement structure is adequate to divert desired discharges
- Preparation of final design sheets indicating key elevations and structural elements
- Construction specifications as necessary to generate bids for replacement structure

Install fish ladders at Smith Diversion structure:

- Design details for retrofitting existing check structures to enable fish passage through check structures used to generate target discharges specified in flow management plan
- Construction specifications for check structure retrofits and fish ladders

Altering channel dimensions in Reaches 2, 3, 4, and 5:

- Final design cross section dimensions based on target discharges specified in flow management plan for Smith Slough and Smith Ditch.
- Hydraulics of 100-year floodplain elevation of existing and proposed scenarios (as required for County Floodplain Permit)
- Construction specifications as necessary to generate bids for habitat enhancement

Install spawning gravels in Smith Ditch

- Finalize location of spawning gravel installation based on hydraulics (depth and velocity) at target discharges specified in flow management plan
- Determine locations where additional cover such as woody debris or shrubs would improve spawning reaches

Relocate Diversion Structure and realign upper Slough (Alt. #1a)

- Hydraulics to ensure new headgate is sufficient to capture target discharges
- Hydraulics new headgate location to ensure replacement structure is structurally stable to withstand the 100-year flood event (as required for County Floodplain Permit)
- Preparation of final design sheets indicating key elevations and structural elements
- Hydraulics of 100-year floodplain elevation of existing and proposed scenarios (as required for County Floodplain Permit)
- Construction specifications as necessary to generate bids for replacement structure
- Finalize new channel alignment, cross section dimensions, and profile
- Construction specifications for excavating and vegetating new channel alignment

Relocate headgate and regrade upper Smith Slough (Alt #1b)

- Hydraulics to ensure new headgate is sufficient to capture target discharges
- Hydraulics new headgate location to ensure replacement structure is structurally stable to withstand the 100-year flood event (as required for County Floodplain Permit)
- Preparation of final design sheets indicating key elevations and structural elements
- Hydraulics of 100-year floodplain elevation of existing and proposed scenarios (as required for County Floodplain Permit)
- Construction specifications as necessary to generate bids for replacement structure
- Excavation volumes for upper Smith Slough regrading

Relocate upper Smith Ditch and re-route irrigation returns to ditch lateral (Alt. #2)

- Finalize relocated channel alignment, cross section dimensions, and profile
- Hydraulics of 100-year floodplain elevation of existing and proposed scenarios (as required for County Floodplain Permit)
- Construction specifications for excavating new channel alignment and plugging deactivated channel segment

Relocate downstream extent of Reach 5 (Alt #3)

- Hydraulics of 100-year floodplain elevation of existing and proposed scenarios (as required for County Floodplain Permit)
- Construction specifications for excavating new channel alignment and plugging deactivated channel segment

Additional Project Details:

- Determine location for placement of excess excavated materials
- Material quantities and sizes (spawning gravels, riprap, sod mats, gravel bars, seed, etc.)
- Finalize material borrow locations (sod mats, woody debris, spawning gravels)

- Quantify areas of impact to jurisdictional wetlands and waterways
- Determine any project-wide construction specifications (equipment access routes, reclamation requirements, storm water protection measures, etc.)

8 Costs

Estimated costs for implementing proposed habitat enhancements on the Smith Slough and Smith Ditch, and alternatives #1-3 are provided in the following tables.

Big Hole Side Channel and Smith Ditch Fisheries Enhancements				
Item	**Qty**	**Unit**	**Unit Price**	**Cost**
Reach 1 - Replace Smith Ditch headgate	1	EA	$ 7,500	$ 7,500
Reach 2 - Install denil fish ladders	2	EA	$ 2,500	$ 5,000
Reach 2 - Channel narrowing	800	FT	$ 15	$ 12,000
Reach 3 - Adult and overwintering pool habitat enhancement	11	Pools	$ 550	$ 6,050
Reach 4 - Construct narrower channel and pool enhancement	1500	FT	$ 15	$ 22,500
Reach 5 - Construct narrower channel with pool enhancement	2000	FT	$ 15	$ 30,000
			Subtotal - Big Hole Side Channel:	**$ 83,050**
Smith Ditch - Install spawning gravels along 1600' of channel	2000	CY	$ 55	$ 110,000
			Subtotal - Smith Ditch:	**$ 110,000**
Final Design and Construction Specifications				$ 25,000
Permitting (404, 310, 318, and County Floodplain)				$ 8,000
Develop Flow Management Plan				$ 3,000
			Subtotal - Design and Permitting:	**$ 36,000**
			Total:	**$ 229,050**
			10% Contingency	$ 22,905
			Grand Total:	**$ 251,955**

Alternative #1a				
Item	**Qty**	**Unit**	**Unit Price**	**Cost**
Install new headgate on Big Hole River	1	EA	$ 10,000	$ 10,000
Construct new channel and floodplain - upper segment	1000	FT	$ 60	$ 60,000
Construct new channel and floodplain - middle segment	500	FT	$ 35	$ 17,500
Construct new channel and floodplain - lower segment	1500	FT	$ 12	$ 18,000
			Subtotal - Alt #1:	**$ 105,500**
Final Design and Specifications	1	each	$ 10,000	$ 10,000
			Subtotal:	**$ 10,000**
			Total:	**$ 115,500**
			10% Contingency	$ 11,550
			Grand Total:	**$ 127,050**

Alternative #1b				
Item	**Qty**	**Unit**	**Unit Price**	**Cost**
Remove existing Smith Ditch headgate	1	EA	$ 2,000	$ 2,000
Install new diversion, blowout, and headgate on Big Hole River	1	EA	$ 50,000	$ 50,000
Regrade Reach 1 and 2 to provide additional head to Slough	1250	CY	$ 7	$ 8,750
			Subtotal - Alt #1:	**$ 60,750**
Final Design and Specifications	1	each	$ 15,000	$ 15,000
			Subtotal:	**$ 15,000**
			Total:	**$ 75,750**
			10% Contingency	$ 7,575
			Grand Total:	**$ 83,325**

Alternative #2				
Item	**Qty**	**Unit**	**Unit Price**	**Cost**
Construct new channel alignment for Smith Ditch	950	feet	$ 12	$ 11,400
Install earth plugs across channel and swales	5	each	$ 1,000	$ 5,000
Excavate drain ditch from swale to ditch	1250	CY	$ 5	$ 6,250
			Subtotal - Alt #1:	**$ 22,650**
Final Design and Specifications	1	each	$ 8,000	$ 8,000
			Subtotal:	**$ 8,000**
			Total:	**$ 30,650**
			10% Contingency	$ 3,065
			Grand Total:	**$ 33,715**

Alternative #3				
Item	**Qty**	**Unit**	**Unit Price**	**Cost**
Excavate new Reach 5 channel alignment	600	feet	$ 15	$ 9,000
			Subtotal - Alt #1:	**$ 9,000**
Final Design and Construction Specifications	1	each	$ 6,000	$ 6,000
			Alt. 2 Subtotal	**$ 6,000**
			Total:	**$ 15,000**
			10% Contingency	$ 1,500
			Grand Total:	**$ 16,500**

Appendix A

Preliminary Design Sheets
Smith Slough and Smith Ditch Fisheries Enhancement Project